ARTMOMA WORKSHOP ON STIMULI RESPONSIVE DYNAMIC SYSTEMS AND MATERIALS
17-19 APRIL 2023
UNIBO/CNR CONFERENCE CENTER, BOLOGNA, ITALY

ArtMoMa
Artificial Molecular Machines

SCIENTIFIC PROGRAMME

Monday 17 April - Sala Ulisse, UNIBO, via Zamboni 31

14:30 - 15:00: Registration and opening

15:00 - 16:00 Stefano di Stefano: Dissipative Systems Driven by the Decarboxylation of Activated Carboxylic Acids

Break 16:00-16:15

16:15-17:15 Tibor Kudernac: Life-like supramolecular mechanics

17:30 – 19:00: Bologna Tour
19:30: Get-together (aperitivo), "La Scuderia" in Piazza Verdi 2, Bologna

Tuesday 18 April – CNR conference center, via Piero Gobetti 101

09:30 - 10:30 Stefano Corrà: Light-fueled supramolecular pumps
10:30 - 11:30 Ghislaine Vantomme: Synthesis of supramolecular polymeric materials – the interplay between covalent and non-covalent bonds

Break 11:30-12:00

12:00 - 13:00 Job Boekhoven: Regulating supramolecular chemistry and materials with non-equilibrium, fueled reaction cycles

Lunch: 13:15 - 14:45

14:45 - 15:45 Rafal Klajn: Visible light makes azobenzenes SAD
15:45 - 16:45 Arri Priimagi: Case studies on light-driven, self-oscillating soft materials

Break 16:45-17:15

17:15 - 18:15 Akira Harada: Supramolecular actuator based on cyclodextrins and self-healing materials

Wednesday 19 April – CNR Conference Center: via Piero Gobetti 101

09:30 - 10:30 Sijbren Otto: Emergence of life-like features from dynamic molecular networks
10:30 - 11:30 Leonard Prins: Energy-driven self-assembly of functional chemical systems

Break 11:30-12:00

12:00 -13:00 Nadja Simeth: Probing the Biological Machinery with Photochemistry

Lunch: 13:15 - 14:45 - End of Workshop

Day 1 Monday 17 April, Sala Ulisse, UNIBO, via Zamboni 31

15:00 - 16:00 Stefano di Stefano, full Professor of Organic Chemistry, Università di Roma La Sapienza, Italy:

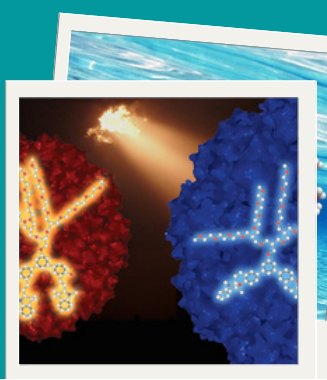
Dissipative Systems Driven by the Decarboxylation of Activated Carboxylic Acids.

The increasing interest towards abiotic systems capable of being maintained in out-of-equilibrium states by means of the consumption of chemical species, is motivated by the aspiration to realize artificial networks with life-like properties. This talk is focused on the use of activated carboxylic acids to drive acid-base operated molecular systems to out-of-equilibrium states and to control the duration of such states under the time.

16:15 - 17:15 Tibor Kudernac, Associate professor Stratingh Institute for Chemistry, Faculty of Science and Technology, University of Groningen, the Netherlands:

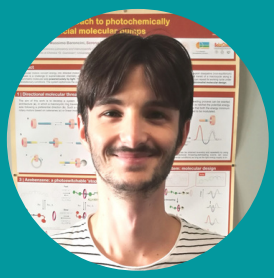
Life-like supramolecular mechanics.

Life has emerged from complex networks of chemical reactions in compartments that gave rise to active mechanics, including growth of these compartments, deformation and divisions, active transport, motility to name but the few. Inspired by this connection between (supramolecular) chemistry and mechanics, our group focuses on developing active supramolecular systems and materials that exert active mechanical forces and adapt as a response to mechanical perturbation from the environment. In my talk I will first discuss the principle behind supramolecular polymerization and de-polymerization motors/machines. This will be followed by describing an example of a de-polymerization machine that can exert measurable mechanical forces and drag macroscopic particles in fluids. Further on, I will explain how we designed a synthetic hydrogel that can adapt to varying mechanical strains by plastic deformation similar to non-crosslinked collagen networks.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie-Sklodowska-Curie grant agreement N°860434

Day 2 18 April - CNR conference center, via Piero Gobetti 101



09:30 - 10:30 Dr. Stefano Corrà, Junior assistant professor, Department of Industrial Chemistry, University of Bologna, Italy:

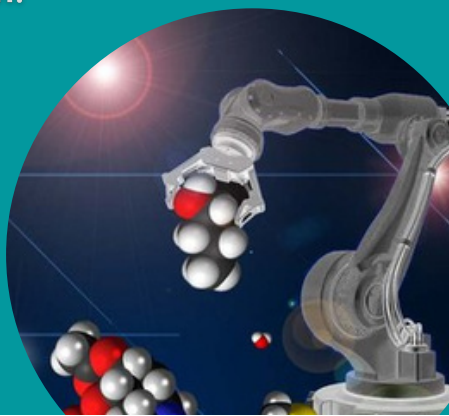
Light-fueled supramolecular pumps.

Natural and artificial autonomous molecular machines operate by constantly dissipating energy from an external source to maintain a non-equilibrium state. The in-depth study of these dissipative states is highly challenging as they exist only as long as energy is provided. We reported on a series of supramolecular pumps that use light to shift a closed reaction network away from (local) thermodynamic equilibrium thanks to an energy ratchet mechanism transducing light energy into chemical energy. Moreover, these pumps realize the unidirectional transit of a ring along an axle. In this talk the structural, kinetics, and energetic aspects of this family of supramolecular pumps will be discussed along with the advancements of the analytical techniques required to reach an unprecedented insight in the non-equilibrium behavior of (photo) chemical reaction networks.

10:30 - 11:30 Ghislaine Vantomme, Dr, Eindhoven University of Technology, Eindhoven, The Netherlands :

Synthesis of supramolecular polymeric materials – the interplay between covalent and non-covalent bonds

To make materials able to sense, move, communicate, and learn requires amplifying molecular events from the nanoscopic to the macroscopic scales. Such a level of control is achieved in nanoscale ordered materials and self-assembly is the common strategy to build these structures with precise molecular arrangement. But, despite the enormous progress, a major goal remains to dictate the molecular organization at mesoscopic levels and to translate and connect these structures to macroscopic function. In this presentation, the focus is on the synthesis of supramolecular polymeric materials and our approach towards adaptive function.



Day 2 18 April - CNR conference center, via Piero Gobetti 101

12:00 - 13:00 Job Boekhoven, Associate Professor in Supramolecular Chemistry, Technical University of Munich, Germany:

Regulating supramolecular chemistry and materials with non-equilibrium, fueled reaction cycles

Molecular self-assembly is the process in which molecules combine into superstructures held together through non-covalent interactions. Over the last decades, supramolecular chemists have perfected this art, and we can now create Gigadalton structures in which each atom is placed with angstrom precision. Nevertheless, we are entirely overshadowed by biology when it comes to assembly with molecular building blocks. Although biology also uses non-covalent interactions to hold molecules together, biological structures are sustained and regulated in the non-equilibrium regime through chemical reaction cycles that convert energy. The implications, rules, and mechanisms there are poorly understood. In this lecture, I will discuss my team's effort to elucidate the rules of non-equilibrium self-assembly fueled by chemical reactions. Next, I will describe a simple yet versatile chemical reaction cycle that can be coupled to self-assembly to create chemically fueled assemblies. Finally, I will highlight some supramolecular materials that can be created from such assemblies, as well as our pathway towards the synthesis of life.

14:45 - 15:45 Rafal Klajn, Professor, Weizmann Institute of Science, Israel:

Visible light makes azobenzenes SAD

In this talk, I will introduce sensitized azobenzene disequilibration (SAD) – a supramolecular approach to switch azobenzenes from the ground state (E) to the metastable state (Z) using visible light of the desired wavelength (including red light). I will show that a combination a coordination cage and a visible-light sensitizer can act together to selectively bind and sensitize E-azobenzenes. Upon switching to the metastable Z isomer, azobenzene loses its affinity to—and is expelled from—the cage, which can then convert additional copies of E into Z. In this way, the cage·sensitizer complex acts as a light-driven supramolecular machine, converting light energy into chemical energy in the form of out-of-equilibrium photostationary states that cannot be accessed directly using visible light.

Day 2 18 April - CNR conference center, via Piero Gobetti 101

15:45 - 16:45 Arri Priimagi, Professor, Tampere University, Finland:

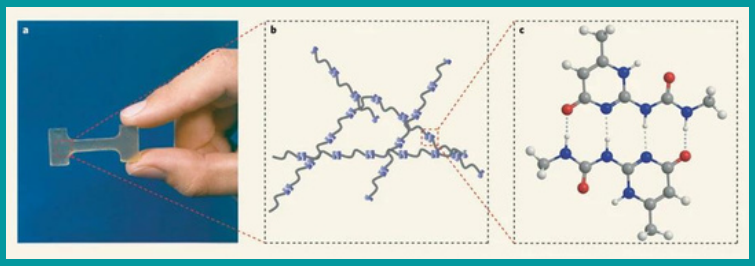
Regulating supramolecular chemistry and materials with non-equilibrium, fueled reaction cycles

Our research activities cover broad range of activities related to light-responsive soft matter, from synthesis of molecular photoswitches to their use in soft-matter photonics and robotics. From the perspective of both life-inspired materials design and realization of autonomous soft-robotic systems, self-oscillation (periodically varying output in response to constant input stimulus) is a particularly intriguing phenomenon that is receiving increasing attention throughout the globe. This presentation showcases some of our recent studies in photothermally driven systems, targeting towards (i) nonreciprocal self-oscillation in liquid crystal networks in submerged conditions, and (ii) feedback-driven hydrogels displaying homeostatic temperature oscillations and dynamic functionalities.

17:15 - 18:15 Akira Harada, Professor ,The Institute of Scientific and Industrial Research, Osaka University, Japan:

Supramolecular materials and actuators based on cyclodextrins

Supramolecular polymers and materials have been designed and prepared using macromolecular recognition by cyclodextrins as host parts. Polyrotaxanes, tubular polymers, supramolecular machines, artificial polymerases have been obtained by main-chain recognition. Macroscopic-self-assembly, self-healing materials, sol-gel transition, muscle-like materials have been achieved by side-chain recognition. End-group recognition leads to the construction of supramolecular polymers in narrow sense.



Day 3 19 April - CNR conference center, Piero Gobetti 101

09:30 - 10:30 Sijbren Otto, Professor of Systems Chemistry, Gröningen University, The Netherlands:

Emergence of life-like features from dynamic molecular networks

Our research activities cover broad range of activities related to light-responsive soft matter, from synthesis of molecular photoswitches to their use in soft-matter photonics and robotics. From the perspective of both life-inspired materials design and realization of autonomous soft-robotic systems, self-oscillation (periodically varying output in response to constant input stimulus) is a particularly intriguing phenomenon that is receiving increasing attention throughout the globe. This presentation showcases some of our recent studies in photothermally driven systems, targeting towards (i) nonreciprocal self-oscillation in liquid crystal networks in submerged conditions, and (ii) feedback-driven hydrogels displaying homeostatic temperature oscillations and dynamic functionalities.

10:30 - 11:30 Leonard Prins, Professor, Department of Chemical Sciences, University of Padova, Italy:

Energy-driven self-assembly of functional chemical systems

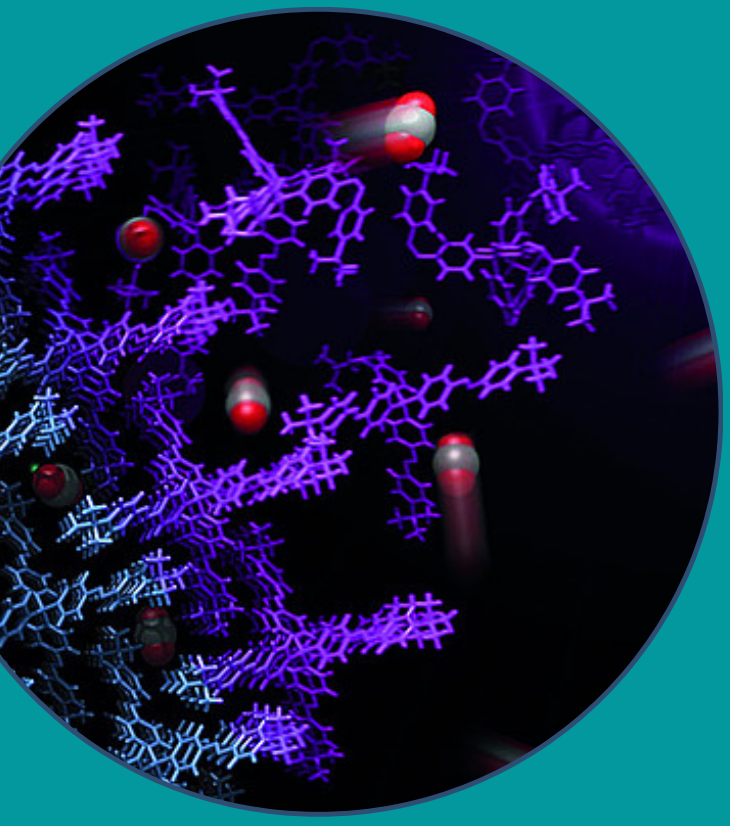
Supramolecular chemistry is rapidly moving into new territory in which the composition of a dynamic system is no longer determined by the relative thermodynamic stabilities of the components, but by the capacity of the components to populate high-energy kinetic states exploiting energy-dissipating processes. This capacity implies that such systems may store and transfer energy, which would bring us closer to implementing the marvelous properties of living systems in synthetic ones. In this presentation I present our recent research aimed at exploiting energy for the activation of functional chemical systems on both the molecular and macromolecular scale.

Day 3 19 April - CNR conference center, Piero Gobetti 101

12:00 - 13:00 Nadja Simeth, Jun.Professor, Institute for Organic and Biomolecular Chemistry, Georg-August University of Göttingen, The Netherlands:

Probing the Biological Machinery with Photochemistry

Light is a privileged external stimulus due to its unparalleled spatiotemporal resolution and traceless nature. It thus has been employed to photo-control diverse functional processes employing molecular units that effectively absorb light, such as photoremovable protecting groups and photoswitches. Especially, embedded into bio-active small molecules or bio-marcomolecules, these photoactuators can be used to probe and control the biological machinery by photochemical means.



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